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THE USE OF INDUSTRY-GOVERNMENT-UNIVERSITY COMMITTEES IN TECHNOLOGY PLANNING: NACA EXPERIENCE RELEVANT TO MORE EFFECTIVE EXPLOITATION OF NASA TECHNOLOGY

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by

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The recognized, growing need to do a more effective job of commercializing America's great store of technology has stimulated more intensive exploration of what might be done. Increasingly, attention has been turned toward various efforts to tap the technology being developed in Federal laboratories or financed by Federal agencies. How can this technology be transferred and used?

Nearly 25 years of experience with NASA's formal technology utilization program has demonstrated the potential, but also the difficulty of such efforts. There is a general consensus that the more a potential user knows about a technology being developed, and has some human or institutional link to the place of development, the greater the assurance of successful transfer.

One potential mode for facilitating technology transfer that NASA has yet to explore is the use of groups of well-qualified technical people from organizations that are potential users of NASA technology--to provide systematic advice <u>at the technical program planning stage</u> on which technologies may have potential "spinoff" or secondary use. NASA has an analog in its predecessor agency (the National Advisory Committee on Aeronautics--NACA) where broadly-based technical committees participated in the agency's planning process.

> "Close contact with the problems of industry and with those of military services and commercial operators is maintained through the functioning of the various subcommittees of the NACA, which consist of experts from every branch of aviation in the country, including industry engineers, military personnel, educators, and members of various Government departments having a qualified interest in the program of aeronautics."[1]

It is this, almost legendary, reputation of the NACA for the effective melding of expertise from industry, university, and government into an outstanding aeronautics (principally aerodynamics) research program during the three decades that followed World War I which gives rise to the question of whether or not a similar committee mechanism might be practical and useful to NASA today as part of its effort to more effectively exploit NASA technology in commercialization and technology utilization activities.

The idea here is not to suggest an undifferentiated application of the NACA technical committee system to current NASA activities. The two agencies, and the environments in which they operate, are significantly different. In a like manner, the use to which such committees would be put significantly vary from the NACA technical committees. These aspects will be discussed later. However, it is important to understand how the NACA technical committees really worked in order to judge the relevance of such structures and processes today, rather than to rely upon misty hearsay and general reputation which may attribute too much to the "good old days," or, on the other hand, may precipitously dismiss the value this committee process had in its time and place.

The general plan of this study and presentation is three fold:

(1) To describe as accurately as possible from reports, memoranda, scholarly works, and interviews with selected actual participants in the committee structure, a description of how the technical committee system operated in NACA, and what lessons might be drawn from that.

(2) Based upon examples of current or recent NASA technical planning processes, describe this process and what opportunities it may hold for more effective exploitation of NASA technology.

(3) Finally, to suggest feasible options for more intensive evaluation or pilot testing.

Two important caveats need to be kept in mind throughout the remainder of this paper. First, the purpose of the NACA technical committees (and their subcommittees) is different from the suggested use of a similar system in the future. In the case of NACA, the committees provided important technical advice to the NACA "Main Committee," on what research should be undertaken in the NACA laboratories based upon the committee's assessment of the general status of aeronautical research, problems encountered within the industry (and the military services), and opportunities for further progress. On the other hand, the suggested purpose of similar committees now would be directed toward bringing technical experts together to review current and planned NASA-sponsored research for potential technology utilization opportunities--and thereby, to approach such research in a manner that would maximize those opportunities without intruding unduly upon the principal mission involved.

A second major consideration is to keep in mind the substantially different nature between NACA and NASA. For most of its life, NACA was a small, low-visibility organization whose activities were carefully limited (most of the time) to "generic" research in the field of aerodynamics. (As used here, aerodynamic research includes studies relating to aircraft performance, stability and control, flying and handling qualities, gust and maneuver loads, propeller performance, and engine cooling. In later years propulsion, structures, and materials become active fields of NACA research.) This was a deliberate choice on the part of the leadership of the organization to avoid conflicts that occurred both within the military and in the aviation industry. Thus, until the late 1930s, and the increasing concern about aviation progress preceeding the outbreak of World War II, NACA rarely engaged in research involving power/propulsion or structures. Virtually all research was conducted in-house. In contrast, NASA was created amid the strong political currents and heavy public concern following Russia's launch of Sputnik and the general public conception that the U.S. was behind the Soviets and needed to catch up. In this political/public environment, NASA was highly visible, received significant appropriations, and was expected to cover virtually all fields of technology relevant to space flight and aviation except those directed specifically to military applications. Even here, the line drawn was not so clear as to preclude close cooperation between NASA and the military services. In addition, although its government facilities were to be expanded substantially, NASA would be conducting the bulk of its research and development activites through contract with the aerospace industry and others--much as the Defense Department did in its acquisition of weapons. NASA was to be a high powered executive agency led by an administrator with full power to act in contrast to the NACA which, though having a research director and executive secretary, was guided and substantially influenced by its "Main Committee," with a substantial diffusion of authority and responsibility.

As different as these two organizations and their respective environments have been, there remains a common heritage and practice of emphasizing research, pushing technology, being open to advice from peers of the highest caliber, and seeking practical, useful results in the application of the agency's work.

I. The NACA Committee Experience

The National Advisory Committee on Aeronautics was established in 1915, and ceased to exist on October 1, 1958, when it was incorporated into the newly formed National Aeronautics and Space Administration. This review of the NACA committee system will concentrate upon the two decades between

1920 and 1940, often described as the "golden age" of aeronautical research between the end of World War I and World War II. The review will be presented in three parts: First, a brief description of the environment in which NACA was created and operated for more than 50 years; second, the evolution of NACA as an agency and its committee system over that period; and third, a general assessment of what was accomplished by the committee system, its strengths and weaknesses.

NACA's "Environment": 1915-1958

NACA came into being largely because of the efforts of a small handful of scientists interested in seeing the new technology of aeronautics progress, along with a small group of aviation enthisiasts which included Naval and Army officers, private citizens, and those interested in exploiting commercial aviation through manufacturing or the provision of services. Although the first successful flight of a heavier than air machine had been made in the United States by the Wright brothers in 1903, it was not until 1909 that an agency of the U.S. government (Army Signal Corps) took delivery of its first airplane. In the meantime enthusiasts in Europe, including governments, had moved much more rapidly to exploit this new technology. As World War I began in Europe, those who understood the potential of aviation in the United States were increasingly concerned about the need for the United States to "catch up" with technology that they saw as originally American.

Thus, NACA was established, principally because of concern with national security questions, but at a low level of expenditure ($5,000 for the first year), and with very little public visibility. World War I saw a significant increase in spending in the United States for aviation--as much as $1 billion being appropriated for use by the Army and Navy--yet the U.S. capability to produce aircraft and to produce them in both quantity and quality consistently lagged behind Europe. This period, and even that stretching into the mid-twenties could be characterized as a "cut and try" approach to designing and building aircraft. Research and performance data were very scarce and often not shared. It was into this environment that the NACA stepped to provide a national focal point for aeronautical research.

After the big spending of World War I, the industry virtually collapsed. With the signing of the armistice, the demand for military aircraft dropped off, and national pacificist sentiments kept demand at a low level in subsequent years. Without government support, the aviation industry was in trouble, and as NACA repeatedly warned the President, the nation was in danger of losing its industrial nucleus which could be expanded in the event of war.

Several events occurred in the mid-1920s which stimulated growth of commercial aviation. In 1925, Congress passed the Kelly Bill, which provided for contracts with private carriers to fly the airmail routes. Previously airmail had been pioneered by using government (Army) aircraft and pilots to pioneer techniques of cross country navigation. In 1926, the Air Commerce Act was passed. This law, in effect, gave legal status to flying by outlining provisions for inspecting and regulating commercial aircraft, for developing airways, and created a new Assistant Secretary of Commerce for Aeronautics. Also in 1926, the Army and Navy adopted five-year programs for the purchase of aircraft. These three actions by the government boosted demand for aircraft and flying services while providing for regulation of flight. Then in 1927, Charles Lindbergh's flight across the Atlantic ignited public interest in flying and in turn, stimulated investment in this new industry.

The Great Depression witnessed a shakeup in the aviation industry, resulting in the consolidation of many small companies for both manufacturing and service purposes. In 1934 an airmail scandal broke wherein air carriers were accused of cheating the government on their airmail contracts. This was accompanied by the rise of monoply situations in the air carrier industry. There followed an investigation by a special commission appointed by President Roosevelt. This ad hoc group, the Federal Aviation Commission, presented its report on the status and needs of civil aviation in 1935, just about the time that leaders in Europe and a few in the United States were beginning to be concerned about the extensive technical progress and buildup of military aviation in Nazi Germany. As described by Levine,

> "What impressed the members of the Commission most as the result of their study was the inter-relationship between commercial, military, and other phases of flying, and the importance of developments in one phase to others, and to national defense."[2]

Leaders in American aviation responded, as did a number in government, so that important, but not publicly visible, actions began to move in both the research and production sides to overcome some of the past deficiencies in the development of aviation technology. There appeared to be more concern in advancing the technololy and its application than there was in the various parochial concerns of the research community, commercial industry or the military services. During World War II all were concerned with production and pushing technology.

At the conclusion of World War II there was a temporary letdown as there had been in World War I with respect to government contracts. However, the use of aviation in war had demonstrated its great flexibility and potential so that there was a great expansion of civil aviation after World War II, building on technology that had been developed for the military. This included the establishment of more research facilities outside of the NACA ambit, even in private industry. No longer would NACA have a near monopoly on "unique" facilities for conducting research and development in the field of aviation.

The Evolution of NACA and the Committee System

The original National Advisory Committee for Aeronautics consisted of 12 members selected from government agencies and private life. Membership later was expanded from 12 to 15, although the structure of membership did not change. The committee included representatives from Army, Navy, the Smithsonian Institution, the National Bureau of Standards, the Weather Bureau and the Department of Commerce. Five of the committee members were men from private life, ". . . acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences."[3]

Of these five members from private life, four of the original members were from universities and one was a layman. These were not industry representatives. The NACA annual report of 1926 says of these members, "These latter, five in number, are not connected with aeronautics as a business but are men of science who have been appointed by the President because of their knowledge of aeronautical science."[4] According to Alex Roland, industry representation on the main committee was banned in order to avoid domination of the committee by private interests, particularly the aircraft industry.[5]

Beneath the main committee, four technical committees emerged, and within those, a number of technical subcommittees. Membership on these committees was similar to the main committee in structure, except that industry representatives gradually found their way into the subcommittees. Originally, industry members were recruited for their technical expertise, and by World War II, they were serving on the main committee.[6]

The subcommittees were one source of research planning. This process is described in the annual report of 1923:

> "As a rule, the technical subcommittees, including representatives of the Army and Navy Air Services, prepare programs of research work of general use or application, and these problems, when approved by the NACA furnish the problems for solution by the Langley Memorial Aeronautical Laboratory."[7]

The Army and Navy often made separate requests for assistance in studying special problems, and the committees would include this work in their research agenda. Industry could enlist NACA's help on particular problems, provided that the firm agreed to defray the cost of using NASA's facilities.

In the early years of NACA (through the mid-1920s), industry's role in research planning was negligible. The industry was small, and most of its business depended on the military needs of the government. Thus, "industry needs" were rarely distinguishable from the needs of the Army and Navy. The annual report of 1926 acknowledges this situation:

> "Up to the present time the greater part of the productive thought and energy of those interested in the development of aviation has been devoted to the interests of military and naval aviation. In this respect the problems of the manufacturers and of the government were largely merged and came under regular consideration by the committee through its subcommittees."[8]

As a commercial aviation industry evolved, the need for devoting attention to industry became apparent. Industry took a more prominent role in research planning through several channels: (1) participation in the technical subcommittees, (2) attendance at the Annual Engineering Conferences (begun in 1926) and technical conferences (1935), (3) liaison through the Research Coordination Office (1940), and (4) participation in the Industry Consulting Committee (1944).

Technical Committees

The technical committees brought together experts from government and industry to investigate areas of particular concern. The four principal technical committees concentrated on the following areas:

- Power plants for aircraft,
- Aerodynamics,
- Aircraft construction,
- Operating problems.

Within the framework of these four areas, subcommittees were established to investigate such issues as Meterological Problems and Coverings, Dopes, and Protective Coatings. For some of these committees, industry representatives provided an important service of technical expertise. The Committee on Materials for Aircraft, for example, included representatives from the American Magnesium Corporation and the Aluminum Company of America.[9]

While the subcommittees studied a range of topics, their functions were fairly uniform. These were:

- To aid in determining problems,
- To coordinate research,
- To act as a medium for the interchange of information,
- To meet and report on committee actions and recommendations.
- To endorse research programs proposed by NACA field staff. (This was viewed by NACA engineering staff as one of the more important functions.)

The technical subcommittees met at least twice a year, and sometimes more often.

These committees proliferated as aeronautical research grew more complex, increasing from nine (9) committees in 1921 to 29 in 1955. The number of positions on these technical committees rose from 79 in 1918 to 652 in 1958, thus providing more opportunities for industry participation.[10]

The Federal Aviation Commission which investigated the general state of aviation in the U.S., and made its report to President Roosevelt in 1935, was concerned with gathering war clouds in Europe and the apparent arm's length relationship between NACA (the nation's principal aeronautical research group) and the aviation industry. Arthur Levine observed:

> "To bring industry into closer relation with NACA activities, the Commission advised the NACA to 'extend its mechanism of unpaid subcommittees to include frequent conferences upon particular questions with technically qualified representatives of the commercial industry, and to draw the industry's personnel engaged in the development of aeronautical products more directly into the planning of its research work.'"[11]

Special technical conferences were instituted by NACA in 1935, and the NACA technical subcommittees gradually acquired more experts from industry.

The problem of "what to study?" was not particularly complex during the early years of flight. The annual report of 1924 states:

> "A study of the present state of knowledge in aerodynamics and the limitations imposed on the performance that can be obtained with the present airplane, discloses the lines along which future investigations must be carried out."[12]

As the "state of knowledge" expanded and configurations of "the present airplane" multiplied, the lines of future investigations multiplied as well, leading to the proliferation of subcommittees.

Some conflict between basic research and "chore-doing" was inevitable, given the differing missions of NACA and its clients (industry, Army and Navy). NACA was charged with the mission: ". . . to supervise and direct the scientific study of the problems of flight, with a view to their practical solution," but actual development was left in the hands of industry. For NACA engineers, industry's requirements often may have seemed a tedious distraction from more glamorous research issues. Looking back on his NACA experience, Jerome C. Hunsaker wrote:

> "What we must avoid is centralized control of the exploration of ideas by the people responsible for immediate needs. There is nothing more discouraging to an engineer than the statement: 'We have no requirement for what you are thinking of.'"[13]

NACA engineers were masters of the art of serving more than one purpose in a particular data collection effort or research task. It should also be kept in mind that builders and operators were hungry for data, so apparently mundane tests of a particular airfoil, for example, were valuable in the accumulation and analysis of more generic phenomena. Such tests also contributed to enlarging knowledge regarding the techniques of instrumentation and measurement. The NACA research engineers who participated in committee and subcommittee activities had considerable influence on the ultimate research agendas. Joseph S. Ames noted this in the 1923 annual report (and this view continued to reflect the philosophy within NACA at both the working and leadership levels):

> "It is true that we can often inspire these questions, and we can always, in the process of obtaining the answers, learn more than is required for the specific purpose. It follows, that while we are conducting parochial tests we are also doing fundamental scientific work continuously."[14]

The NACA facilities, at Langley and later at Ames and Lewis, provided an incentive for industry cooperation with NACA. These facilities often were the most sophisticated--and sometimes the only--equipment of their kind available to American industry. Furthermore, it was considered an honor to serve as a NACA member along side such associates as Orville Wright and Charles Lindbergh, and the meetings provided a way of staying current in aeronautics research.[15]

The annual report of 1924 attributes the success of NACA and its subcommittees to the following factors:

- Service without compensation, which enables the government to receive the services of "men who would not otherwise be available,"
- NACA's independence as a government establishment, reporting directly to the President with appropriations from Congress,
- NACA's freedom to initiate and conduct any investigation considered fundamental or desirable.[16]

The Annual Engineering Conferences

The timing of the first Annual Engineering Conference, held in 1926, corresponded with the emergence of a commercial aviation industry. The annual report of 1925 took note of the emerging commercial industry and proposed the annual conferences as a means of learning industry's needs:

> "The committee is of the opinion that with the advent of commercial aviation, a new series of problems peculiar to commercial aircraft will be presented. The committee therefore has decided to hold one or more meetings annually with the engineering representatives of aircraft manufacturing and operating industries, with a view to ascertaining definitely the problems deemed of most vital importance and incorporating the same, as far as practicable, into the general research programs prepared by the committee."[17]

Becker presents the purpose of the engineering conferences from a different point of view. He notes that technical documents often went unread, and as a result, there was a risk that NACA's accomplishments would go unnoticed by industry or Congress. This concern led to formation of the engineering conferences:

> "Starting in 1926, the so-called Engineering Conferences provided periodic opportunities to highlight recent research accomplishments, and at the same time to 'blow the horn' for the agency in a most effective and unobnoxious way."[18]

He describes the NACA staff as taking care to make their presentations simple without sacrificing important technical implications.

Whether NACA's intention was to learn of industry's needs or to publicize its own accomplishments, the conferences served as a means of exchanging information, and they were well attended by industry. By 1936, it was necessary to hold the conferences in two sessions in order to accommodate the large number of attendees.

A typical conference included a presentation by NACA and a tour of the Langley facilities. Representatives from industry were given an opportunity to present suggestions for research by NACA. Many of the problems presented were already under study by NACA; others would be added to the research agenda. Typically, 20 or 30 suggestions were offered, of which two or three would be added to an appropriate committee's workload.

The last annual conference was held in 1939. The construction of facilities at Langley in anticipation of war, then the war effort itself, made continuance of the conferences impractical. By that time, aeronautic issues were becomming too complex to handle in a single conference anyway. NACA continued to hold smaller special conferences however. These conferences brought together experts to discuss a topic of technical concern. Nine such conferences were held in 1948, four in 1952, and two in 1953.

These conferences, along with site visits and industry participation in the subcommittees, ensured industry input to technology planning.

World War II afforded plenty of opportunity for contact between industry and government. Both parties were involved in a crash effort to build and improve aircraft, with industry constantly consulting government on contract specifications and aircraft performance. While some basic research continued during these years, most technology planning took the form of efforts to fix existing problems as quickly as possible.

Research Coordination

A Coordinator of Research was appointed in 1940 as a liaison between NACA, industry and the universities. This officer visited universities and companies, reporting to them on NACA activities and learning of their activities to report back to NACA. When appropriate, he would organize conferences on problems of special interest or arrange for NACA personnel to visit industry facilities. In some cases, the coordination staff was able to offer direct engineering assistance in addressing manufacturing problems, and in others, they were able to accelerate the handling of problems by NACA staff. The national war effort added impetus to these efforts to transfer technology.

Industry Consulting Committee

The Industry Consulting Committee was created in 1944 to ensure that the needs of industry were incorporated in research policy. As stated in the annual report of 1947, "The purpose of this committee is to advise the NACA on the problems of aeronautical research in which the aviation industry is most interested."[19] Membership consisted solely of representatives from industry.

NACA Committees: Strengths and Weaknesses

In retrospect NACA has been criticized in recent years (compared to NASA) as being limited in its perspective, cautious and unduly conservative. Homer Newell, a NASA senior official for some 15 years noted that, at the time the President and the Congress were considering what organizational steps might be taken to boost space science activity in the United States following the launch of Sputnik in the fall of 1957, NACA was not a foremost candidate.

> "The NACA would not have been the choice of most scientists. As a higly ingrown activity, the agency did not enjoy a particularly great esteem in scientific circles, being thought of more as an applied research activity serving primarily industry and the military. Members of the Rocket and Satellite Research Panel, in particular, were skeptical of the ability of an agency almost entirely oriented toward in-house research and with no experience in the management of large programs to take on all the research, development, and operational tasks of a space program that some members thought soon would entail $1 billion a year. . . .
>
> The views of scientists probably carried little weight. More telling was the disenchantment with NACA on the part of its own clients, the Air Force and industry. The agency had started in 1915 as an advisory group, as its name implied, but became gun shy when its advice began to generate at least as many enemies as friends. As a consequence the NACA soon turned away from advising and toward research. Even here it was necessary to keep from treading on the toes of either industry or the military, and as a consequence the agency gravitated toward aerodynamic and wind tunnel research, in which both clients were happy to have help. Over the years the agency had acquired a reputation of caution and conservatism. This conservatism may have caused NACA to miss out on a number of important aeronautical advances, the most significant of which was jet propulsion, where Britian and Germany took the lead."[20]

This judgment of narrow conservatism needs to be tempered by a full appreciation of the times in whch NACA was created and grew up. There were excellent political, economic and operational reasons why NACA limited itself principally to aerodynamic research. Levine explains:

> ". . . . NACA leaders felt that an extensive research effort in structures or propulsion would involve the agency in controversies with the aircraft industry. Firms engaged in the manufacture of engines and air frames were fierce competitors and NACA leaders feared that the research efforts in these fields would become entangled with proprietary problems and disputes on design of specific engines or air frames."[21]

There was little or no pressure from either the military (both Army and Navy) or industry (both aircraft manufacturers and airlines) to develop new power plants or new air frames. The aircraft industry was not interested in substantial leaps in aeronautical technology which would make obsolete their sunk investment in current designs and models. Many of these companies operated on financial shoe strings. In addition both the Army and the Navy were operating within very tight budgets which encouraged a conservative stance. Then too, NACA had to consider that branching out into aircraft engines and air frames was a more expensive research and development area than that of building and testing models in wind tunnels, with confirmatory tests and instrumentation of aircraft in flight.

Basically, it was these types of considerations that limited NACA involvement in aircraft power plant or air frame research until the exigencies of oncoming war in the late 30s significantly expanded NACA programs and funding, and led to the creation of two new research centers, one for power plants (Lewis Research Center), and the other for further aerodynamic work on the west coast (Ames Research Center).

However, returning to the main point of the work of the NACA committees, few historians of NACA or long-term employees who actually experienced work with the committee structure believe that the technical committee system contributed very much to the NACA reputation for caution and conservatism.

On the negative side one cannot ignore the fact that a committee approach (in contrast to a unitary executive) often tends toward a "lowest common denominator," in order to achieve action through some form of compromise. However, the record does not reveal any significant impact, because of the committee structure or makeup, creating a conservative approach to aeronautical research.

A second factor which may have reduced the innovative opportunities for such technical committees was the concern at the NACA policy level of the potential for "conflict of interest" in technical committees--especially for those individuals who were active in industry. The concern was that some companies might achieve a technical windfall by having access to technology discussions in the planning stage as a member on one of the technical committees or subcommittees. Those who participated from the NACA's side in the committee system at the working level uniformly disagreed that this was a problem, though they would agree that, theoretically, it could occur.

On the more positive side, the technical advisory committees had at least three advantages for NACA. First, they provided a vehicle for the systematic involvement of subject matter experts wherever they might be--from government, from universities, and from industry. Second, the research agenda of NACA was influenced by "real world" problems as seen by persons who had an every day contact with problems of the aviation industry.

Third, participants were selected for their knowledge/expertise that they brought to the committee, not as institutional representatives. This gave NACA access to those persons who represented the greatest depth of experience and knowledge.

Finally, it should be emphasized, as confirmed by those who actually participated in the committee process, that these advisory committees did not run NACA research and development. They had an influence, and made important inputs to the technology planning process which undoubtedly modified research agendas in the direction of operational problems. Indeed, NACA leadership was acutely sensitive to the fact that the continued existence of the NACA research program depended largely to the extent of the satisfaction of their "client groups"--namely the aviation industry at large and the air services of the Army and Navy. On balance, it can be said that the technical committees provided an important dimension in the promotion and planning of aeronautical research in the United States.

II. NASA Technical Planning

As one might anticipate NASA technical planning has proved to be considerably different from that experienced under the National Advisory Committee on Aeronautics. The reason is straightforward: NASA is more typical of an executive agency with a single administrator as its head, in contrast to NACA which was a much looser committee-executive secretary type of arrangement. This was clearly revealed during the Congressional debate in 1958 as to what form the new space agency should take. It was recognized by all parties that the organization would be considerably larger than the old NACA, that it would deal with much larger amounts of money, and that it, in all likelihood, would be doing the majority of its work via contracting. Given these circumstances, there was the strong urge to provide clear points of responsibility, and a management system which would be conducive to clear decision-making, rather than one that appeared to be more consensus-based.

As a result, the agency authority and responsibility is vested in the Administrator. NASA did not completely throw off the use of advisory committees and subcommittees in its technical planning, carried over from NACA, but it did downplay this type of planning and operational attitude. NASA operates much more like other executive agencies in that all types of planning, from long range and the most conceptual down to the most detailed, tend to flow from those agency officials responsible for particular program areas. Advice and technical input is used from sources outside of NASA; however, those who experienced the committee system under NACA, testified to the fact that there tends to be a much stronger emphasis on centralized planning from NASA Headquarters than ever occurred under NACA.

Basic NASA Technical Planning

For broadest-goal setting and conceptual planning on a broad gauge basis, NASA has what amounts to a "senior management council" that loosely consists of the Administrator and his immediate staff, the Associate Administrators, and the Field Center Directors. These individuals give principal direction to NASA as an agency in its technical program thrust. This general type of approach is mimicked at the major program levels.

Since the purpose of this review is principally technology planning, attention will be focussed upon the Office of Aeronautics and Space Technology (OAST) as our basic model. Here the senior management--which includes major program and project heads as well as those running major areas of technology--is responsible for long-range guidance, with the input of colleagues or surrogates from the Field Centers that report to OAST.*

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*Ames, Langley, and Lewis.

There are two sets of plans involved on an annual basis. The first is the Research and Technology Objective and Plan (RTOP) process. This looks at areas of research and technology where the emphasis is placed upon innovation and risk taking. The objective is defined, but the work plan is kept relatively flexible. The RTOP process begins with the headquarters program offices which issue conceptual planning and RTOP guidelines. These guidelines reflect input from the Field Centers as well as from technology advisory groups consisting of members from both NASA and from outside the agency (more will be discussed of such advisory groups later). The Field Centers have the responsibility for developing the individual RTOPs and making resource estimates. Once Headquarters has reviewed and approved these RTOPs, the Field Centers execute them on the basis of the particular fiscal year plans. NASA Technical Memorandum 83090 (1981), "The Planning and Control of NASA Programs and Resources," defines these activities as:

> "The RTOP process covers all those activities that have as their objective the acquisition of specific knowledge, information, techniques, data, systems, etc., that will provide a capability for future experiments, developments, applications, etc., in support of agency goals. Included in this category are fundamental research, discipline technology, systems technology, experimental programs, systems study, payload definition activities, etc."[22]

The second area deals with more detailed program and project planning. The process often begins at the Field Centers, which conduct preliminary investigations of the feasibility of ideas generated through research and development. Once Headquarters has reviewed and approved the particular project plan, the Centers proceed with the work, usually with contractor assistance or much of the work being accomplished under contract. The project plan is an agreement between Headquarters and the Field Centers for implementing the project. It specifies how the project will be accomplished and the level of resources required. The PAD or Project Approval Document is the principal authorization for project and program plans. In both the technology planning and the program and project planning, there is considerable give and take between NASA Headquarters and officials in the Field Centers.

In the general planning process, and taking OAST as our model, each Field Center is designated as a "center of excellence" for certain disciplines. Langley Research Center, for example, specializes in such disciplines as aerothermodynamics, large antenna systems, remote sensing, and space electronics.

OAST also puts together and publishes a long-range plan in each of its two major areas of concern: aeronautics, and space research and technology. For example, the introduction to the space research and technology long-range plan describes its basic purpose as:

> ". . . to set forth. . . the overall direction and scope of the program, the approach for its implementation, and the specific actions intended to strengthen and maintain the institutional capability as a major contributing factor to a strong national space effort. . .
>
> The plan represents Office of Aeronautics and Space Technology (OAST) policy as set by the OAST Management Council for Space which consists of the Directors and Deputy Directors of the Ames, Langley, and Lewis Research Centers, the Directors (or their designees) of JPL and the Space Centers (Goddard, Johnson, Marshall, and Kennedy), the Deputy and Assistant Associate Administrators for Aeronautics and Space Technology, and the Associate Administrator, OAST, who is the Chairman.
>
> Within NASA, OAST has the primary responsibility for conducting space R&T in support of rapidly expanding commercial, military, and NASA space interests. In planning the program, OAST consults extensively with other NASA Program Offices, the DOD, and with industry, in order to identify and anticipate technology needs. As the

technology develops, programs are often conducted jointly with the DOD and with other Program Offices to insure efficient and timely transfer of technology to the user."[23]

NASA Use of Advisory Groups

From the outset NASA has used advisory groups of either a continuing or ad hoc nature, to include individuals from other Federal agencies and laboratories, from the aerospace industry, and from universities. The most obvious have been special groups put together by the National Academy of Sciences, the National Academy of Engineering, or special studies conducted for NASA by panels put together by the National Research Council. Such groups help survey specific areas of technology and provide advice for agency goals into the future. In other instances they have provided advice and assessment regarding a particular program area of interest to NASA, or the needs and interests of either industry or academia.

Beyond this NASA also established an advisory committee system based at the top level on what has been called the NASA Advisory Council. This council consists of distinguished private citizens, individuals from private industry and from universities who provide a "big picture" perspective for the Administrator. This includes special tasks (such as one to look at NASA's goals and missions into the future), as well as assisting in periodic reviews of the total NASA program.

This council is assisted by staff assigned to it for ad hoc problems, and by five committees that are subsidiary to the council. For example, one of the committees is the Space Systems and Technology Advisory Committee (SSTAC), and another is the Aeronautical Advisory Committee. The SSTAC has 12 of its members from the university community, 30 from industry, and seven (7) from other Federal agencies and laboratories. In addition there are ex officio members from NASA Field Centers and Headquarters staff that total 51 experts or specialists from the NASA community. This committee has a series of subcommittees to cover various subjects such as Space Systems, Materials and Structures, Space Electronics, Space Power and Electric Propulsion, and Chemical Propulsion, and an executive committee. The Chairman of SSTAC is a prominent individual from an aerospace firm.

In a like manner the Aeronautics Advisory Committee is assisted in its work by a series of informal subcommittees that deal with such technical subjects as: general aviation, aeronautical propulsion, safety, human factors and operating systems, materials and structures, aerodynamics, aircraft controls and guidance, and transport aircraft and the executive committee. In this instance, the Chairman of the Aeronautics Advisory Committee is a prominent scholar from a university. Again, there are ex officio members from the NASA laboratories and Field Centers numbering 46. The full committee includes nine (9) university members, 44 from industry, 19 from other Federal agencies and laboratories and ten (10) persons from industry associations.

Generally, these five advisory committees review programs and evaluate their scientific and technical merit, including some contribution to the question of resource allocation that will occur annually in the budget process. Material and information from these committees is passed along to the Advisory Council which advises the NASA Administrator. The Administrator has compared the Advisory Council to a "board of directors." However, this council has no management decision or responsibility--that rests with the Administrator.

In summary, although NASA continues to use an advisory apparatus that has many of the hallmarks of the NACA committee system, there are at least two significant differences: (1) the organizational and management structure of NASA clearly puts the Administrator and his subordinate program officials in the position of making final decisions where they have full authority and responsibility; (2) the advisory groups are not in a position to set the agenda for research to the same extent that might have been true of the NACA committees and subcommittees so that, although they may have influence because they act as "users" of NASA programs, or represent important consituencies interested in NASA programs, these groups carry no organizational authority in the sense that the main committee did in NACA. In addition, the committees are much larger than were the technical committees and subcommittees under NACA so that the same opportunities for a close working relationship are not present.

One observer of the NASA use of outside advisory groups has characterized NASA's principal practice as one of avoiding any serious dependence on such groups in order to be sure that NASA principal officials would not be "limited" by their recommendations. He concluded that the principal use NASA has made of advisory groups tended to be on a project or program basis so that there rarely has been a general overview into the future of where technology might lead.[24]

III. Options for Pilot Testing and Further Assessment

As NASA satellite programs have matured, and as the Space Shuttle enters its operational mode, it has become more apparent that NASA needs a closer means of linkage to industry and its other users. This philosophy was emphasized in a remark made by former Associate Administrator for Applications, Anthony J. Calio:

> "What we have learned is that if we can get the potential user on-board at the inception of a new technology program and keep him on-board as an active partner, the results will be readily recognizable as profitable benefits, not only to the participants, but to the nation as well. In short, we need you--industry--to work with us to define those technical problems where our unique space expertise can be brought to bear, to work with us in seeking the solutions and to stand ready to put the solutions to work."[25]

This is especially apparent with the new emphasis given to commercialization within NASA's organization.

However, this is also true in relation to the development of specific fields in space technology.

In 1983 the Aeronautics and Space Engineering Board of the National Research Council did an assessment of NASA's Research and Space Technology Program and made the following observation:

> "In the field of aeronautics, NASA has historically provided a central technological resource that U.S. aircraft companies have drawn upon. NASA and its predecessor, NACA, worked effectively and in harmony with the aeronautical communities for two-thirds of a century with resultant strength in U.S. aeronautics.
>
> As discussed above, NASA Space R&T has been tailored to the technology requirements of NASA missions. The following chapters explore the desirability for the NASA Office of Aeronautics and Space Technology (OAST) to conduct the research and provide the technology that will permit the U.S. industry to exploit the use of space for civil and military uses."[26]

Continuing, the board made the following recommendations:

> "OAST's R&T Program Planning would profit from increased external participation: both industry and academe should be involved in helping a time-phase program plan that would be reviewed and evaluated by an independent peer review process. Such a plan should encompass the requirements of NASA, DOD, users in the civil and commercial sector, and the spacecraft manufacturers."[27]

These references indicate the direction that substantial scientific and industrial thinking is taking with respect to the need for NASA to reach out for a wider variety of "users" that should influence major research and technology planning within the agency. Our concern in this paper has been how to influence the regular planning process and the planning of what new technology needs to be undertaken with emphasis upon additional perspectives that might identify the technology potential for future utilization (in other than direct applications), and stimulate in-house recognition and appreciation for such applications. The basic thesis is that although the NACA committee system never had that as one of its purposes, the type of environment in which those committees worked and their close involvement in the technology planning for NACA provided an excellent opportunity to consider such potential.

Clearly, times have changed. NASA is larger, more visible, more involved in the political process, has more funds for which it is responsible, conducts most of its business under contract, and has a much wider variety of technology interests. <u>The question is, given all of these changes, would it be possible for an advisory committee system to perform effectively a responsibility to identify, call attention to, and facilitate technology utilization by being a party to the technology planning process?</u>

Over 20 years of research on the process and conditions for successful transfer of technology suggest that the answer is a strong "yes." The roots that nourished the successful NACA committee system remain healthy within NASA--particularly in the Research Centers. Scientists and engineers there clearly enjoy and are stimulated by interaction with peers from significantly different organizational environments, <u>when addressing common technological interests or problems</u>. Most recognize the process as two-way and mutual. The key is NASA management interest and support. Once such efforts are recognized as not only legitimate, but actively encouraged, they have the real potential for being self-sustaining as members experience the value of such exchanges and this value percolates upward.

There are at least two options for potential test and assessment of this thesis. First, recast one or more NASA Advisory Council subcommittees (at the working level) such as the Materials and Structures Subcommittee of the Aeronautics Advisory Committee, through the addition of non-aerospace industry technology experts in this field. These added members would have two responsibilities: (1) they would add another dimension of experience and expertise in this technical field; (2) they could stimulate the identification of potential areas for future technology utilization, by reviewing the technology plans within that particular subcommittee. The emphasis in this latter role would be on non-aerospace applications.

A second option would be to pilot test one or more technology utilization review committees, patterned on the technical subcommittees that were used in NACA, but with the <u>sole</u> responsibility for identifying and suggesting means to facilitate technology utilization in the future, based upon an annual review of the technology plan in that particular area of technology. Such a committee could be composed of representatives from university, from aerospace and non-aerospace industry, and with technical members from NASA Field Centers or elsewhere. Such a committee could be established at the Headquarters level, or, even at the Field Center level to review only the technology plans related to that field of technology within that Field Center. The latter might be easier to operate and test on a small scale, and with less political visibility, than would one operating agency-wide.

The first option is more likely to be successful in terms of enticing top level experts from non-aerospace industry, because they would have some influence on the NASA technology planning process where their role was not limited solely to identifying the potential for technology utilization. On the other hand, it might be more difficult to gain the acceptance desirable from current members working on such a technical subcommittee, through the addition of individuals who did not seem to be as closely related to the mission objectives and program interests represented by the current membership. The NACA experience suggests that such parochial concerns may be overcome by common technological (in contrast to program) interests <u>if</u> the composition of the committee is based upon technical standing of the individual members rather than institutional or corporate "representation."

The second option is more likely to be successful at the Field Center level where the depth of NASA technical expertise resides. Here NASA staff are used to working "engineer to engineer or scientist to scientist" with less intrusion of institutional concerns. Since these would be new committees, it would offer the opportunity to assure that members were selected on the basis of technical standing, with a larger proportion from non-aerospace industry than might otherwise be possible. Having the opportunity to meet and exchange ideas with technical peers from different program and organizational settings (for both NASA and industry members) could prove very attractive in recruiting committee members.

The proposed options obviously are not mutually exclusive; each could be tried and assessed concurrently or serially, given proper monitoring and preparation for a full trial.* A period of three years should be sufficient to determine the value of either experiment.

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*Such committees as suggested here are not without recent precedent. See the comments on this paper by John E. Duberg, former Associate Director of the Langley Research Center, in Appendix 2.

PERSONS INTERVIEWED OR CONSULTED

Special thanks are due to the following individuals who were kind enough to be interviewed regarding their personal experiences in NACA with technical committee or subcommittee activity. Two groups of individuals were involved: (1) those listed first were interviewed specifically under the study design which produced this current report; (2) another group was interviewed in conjunction with another study, but which focussed on some of the same questions.

Seth Anderson, Research Assistant to the Director, Applied Systems and Simulations Division, Ames Research Center

Dr. John E. Duberg, former Associate Director, Langley Research Center

Melvin J. Hartmann, Director, Research and Technology Assessment, former Director of Aeronautics, Lewis Research Center

Laurence K. Loftin, former Director of Aeronautics, Langley Research Center

Harry L. Runyan, former Chief, Structures and Dynamics Division, Langley Research Center

Blake Corson, former Head, Sixteen-Foot Transonic Tunnel, Langley Research Center

Howard Edwards, former Chief, Instrument Research Division, Langley Research Center

William H. Phillips, former Chief, Flight Dynamics and Controls Division, Langley Research Center

Clarence Syvertson, former Director, Ames Research Center

The following individuals were consulted regarding historical sources, bibliographic and documentary information, as well as substantive interpretation regarding their own historical research in relevant areas.

Dr. James Hanson, Historian, Langley Research Center

Dr. Alex F. Roland, Professor of History, Duke University

Lee D. Saegesser, NASA Headquarters Archivist

Ms. Eleanor Burdette, Systems Support Officer, NASA HQ S&T Library

Ms. Jane Hess, Head, Langley Research Center Library

Ms. Sue Seward, Reference Librarian, Langley Research Center Library

Comments of John E. Duberg,
former Associate Director, Langley
Research Center, on this paper,
April 11, 1985

After a second reading of your paper and a more careful reading of the second part of your title, I concluded the problem you wished to address was how can a committee structure based on some modification of the old NACA committee structure or its derivatives under NASA be developed that could more effectively exploit the research and technology base being developed by the total NASA program. That is Technical Utilization at its highest level. My opinion has been that the best examples of this occur when some human being, adequately informed, perceives how he can solve some pressing and socially desirable need he is aware of by applying that knowledge. It is essentially blending a need with the state of what is achievable or is achievable with an extension of knowledge in the short term. Short term implying before the system has been completely designed and built and ready for operation. My observations at Langley during the decades of 1940 and 1950 were that some of the center leadership served this function for aeronautics. Some examples of individuals are Floyd Thompson and John Stack although I would not limit it to them. I believe another good example was Julian Allen of Ames in the early days of NASA. I would also not want to overlook the industry individuals with whom they had strong contacts and I am sure contributed to the process. On the industrial side individuals such as Kelly Johnson of Lockheed clearly played similar and significant roles.

The principal difficulty at the present time is the enormous breadth of the NASA program and the wide range of industries that could benefit from its efforts. How does one reach out to the multitudes of industries that can benefit but are ignorant of the possibilities?

If a committee system is to be used to provide for the exchange opportunity, someone on the NASA side must be competent enough to know who to invite into the system from the outside. This is easy to do for the large aerospace corporations but the facts seem to indicate that it is from the small and as yet not too visible firms that new application ideas and products come. But perhaps this presents no problem since it would seem the leadership of these small firms are actively pursuing opportunities to exploit new knowledge and already know how to keep informed.

Perhaps an example of what might be done to more rapidly and properly direct development of a product is the Integrated Program for Aerospace Vehicle Design (IPAD) program which attempts to produce an effective all encompassing aircraft design methodology and its integration within all the affected groups in an aircraft company, using interconnected computer systems. With at least the broad objectives in mind an Industry Technical Advisory Board (ITAB) was structured to steer, at several levels of detail and across several disciplines, the on going effort. It was mostly composed of individuals from industries directly involved such as the aircraft industry but also groups that could benefit such as the automobile manufacturers.

FOOTNOTES

1. NACA Report for United States Senate, special committee investigating the National Defense Program, Part 2, January 21, 1946, p. 3.

2. Levine, Arthur L., United States Aeronautical Research Policy, 1915-1958: A Study of the Major Policy Decisions of the National Advisory Committee for Aeronautics (dissertation), Columbia University, 1963, p. 76.

3. Public Law 63,271, March 3, 1915.

4. Annual Report of NACA, 1926, p. 67.

5. Roland, Alex, "The National Advisory Committee for Aeronautics," Prologue, Vol. 10, Summer 1978, p. 72.

6. Ibid.

7. Annual Report of NACA, 1923, p. 6 (emphasis supplied).

8. Annual Report of NACA, 1926, p. 12.

9. Annual Report of NACA, 1928.

10. Roland, op. cit., p. 72.

11. Levine, op. cit., p. 79.

12. Annual Report of NACA, 1924, p. 49.

13. Hunsaker, Jerome C., "Some Lessons of History, Second Wings Club 'Sight' Lecture," May 26, 1965.

14. Annual REport of NACA, 1923, p. 59. Excerpt from a speech by Joseph S. Ames, "Relation Between Aeronautic Research and Aircraft Design," May 31, 1923.

15. Roland, op. cit., p. 72.

16. Annual Report of NACA, 1924, p. 57.

17. Annual Report of NACA, 1925, p. 57.

18. Becker, John V., The High-Speed Frontier, NASA, 1980, p. 76.

19. Annual Report of NACA, 1947, p. 3.

20. Newell, Homer E., Beyond the Atmosphere: Early Years of Space Science, Washington, DC: GPO, 1980, pp. 90-91

21. Levine, _op. cit._, p. 42. This was the policy adopted in the 1920s when there were many many small manufacturers in the business and when NACA "opted" out of a broader national advisory role at the policy level following the Air Commerce Act of 1926.

22. _The Planning and Control of NASA Programs and Resources_, NASA Technical Memorandum 83090, 1981, p. 13.

23. _Space R&D Long Range Plan_, Office of Aeronautics and Space Technology, February 1983, p. 3.

24. See Arnold S. Levine, _Managing NASA and the Apollo Era_, NASA, 1982.

25. _Impact for the Eighties_, p. 197.

26. _NASA's Space Research and Technology Program_, National Research Council, Commission on Engineering and Technical Systems, Aeronautics and Space Engineering Board, Washington, DC: National Academy Press, June 30, 1983, p. 5.

27. _Ibid._, p. 71.

BIBLIOGRAPHY

NACA/NASA Documents

- Annual Reports of NACA, 1917-1958

- NACA Report for United States Senate, Special Committee Investigating the National Defense Program, Part 2, January 2, 1946

- Science and Applications Management, Program Review Document, June 22, 1967

- Phased Project Planning Guidelines, NASA Handbook 7121.2, August 1968

- Planning and Approval of Major Research and Development Projects, NASA Management Instruction 7121.1C, March 24, 1977

- Major System Acquisitions, NASA Management Instruction 7100.14A, April 19, 1978

- Management System, Organizational Climate and Performance Relationships, Bervil D. Davis, NASA Technical Paper 1417, February 1979

- The Planning and Control of NASA Programs and Resources, NASA Technical Memorandum 83090, 1981

- NASA Advisory Council, Aeronautics Advisory Committee Membership, May 10, 1983

- Aeronautics Long Range Plan, Office of Aeronautics and Space Technology, February 1983

- Space R&D Long Range Plan, Office of Aeronautics and Space Technology, February 1983

- NASA Advisory Council Study of the Mission of NASA, October 12, 1983

Reports, Monographs, and Books

- The Aviation Business, Elsbeth E. Freudenthal, New York: Vanguard Press, 1940

- Frontiers of Flight: The Story of NACA Research, George W. Gray, New York: Alfred A. Knopf, 1948

- Aeronautics and Astronautics, An American Chronology of Science and Technology in the Exploration of Space, 1915-1960, Eugene M. Emme, NASA, 1961

- United States Aeronautical Research Policy, 1915-1958: A Study of the Major Policy Decisions of the National Advisory Committee for Aeronautics, Arthur L. Levine (dissertation), Columbia University, 1963

- Fifty Years of Flight Research: A Chronology of the Langley Research Center, 1917-1966, Michael David Keller, NASA Historical Staff, November 1966

- Fifty Years of Aeronautical Research, NASA, Washington, DC, 1968

- Adventures in Research, A History of Ames Research Center 1940-1965, Edwin P. Hartman, NASA SP-4302, 1970

- Orders of Magnitude, A History of NACA and NASA, 1915-1976, Frank W. Anderson, Jr., NASA SP-4403, 1976

- The High-Speed Frontier: Case Studies of Four NACA Programs 1920-1950, John V. Becker, NASA SP-445, 1980

- Beyond the Atmosphere: Early Years of Space Science, Homer E. Newell, NASA SP-4211, 1980

- Managing NASA in the Apollo Era, Arnold S. Levine, NASA SP-4101, 1982

- NASA's Space Research and Technology Program, Report of Workshop, Aeronautics and Space Engineering Board, Commission on Engineering and Technical Systems, National Research Council, June 30, 1983 (National Academy Press, Washington, DC, 1983)

Articles and Papers

-"The Creation of N.A.C.A. and N.A.S.A.," Arthur L. Levine, AIAA Paper No. 67-836, October 1967

-"Some Lessons of History, Second Wings Club 'Sight' Lecture," Jerome C. Hunsaker, May 26, 1965

-"Space Administration Takes Over NACA," Control Engineering, Vol. 5, November 1958, pp. 42+

-"Recollections From an Earlier Period in American Aeronautics," Robert T. Jones, Annual Review of Fluid Mechanics, Vol. 9, 1977, pp. 1-11

-"Space Technology and the NACA," Hugh L. Dryden, Aeronautical Engineering Review, Vol. 17, March 1958, pp. 32-34+

-"The National Advisory Committee for Aeronautics," Alex Roland, Prologue, Vol. 10, Summer 1978, pp. 69-81

-"My Early Aerodynamic Research--Thoughts and Memories," Max M. Munk, Annual Review of Fluid Mechanics, Vol. 13, 1981, pp. 1-7

-"Early History of the Space Age," Eugene M. Emme, Aerospace Historian, Vol. 13, No. 2, Summer 1968, pp. 74-78, and No. 3, Autumn 1968, pp. 127-132